P 6.1.2

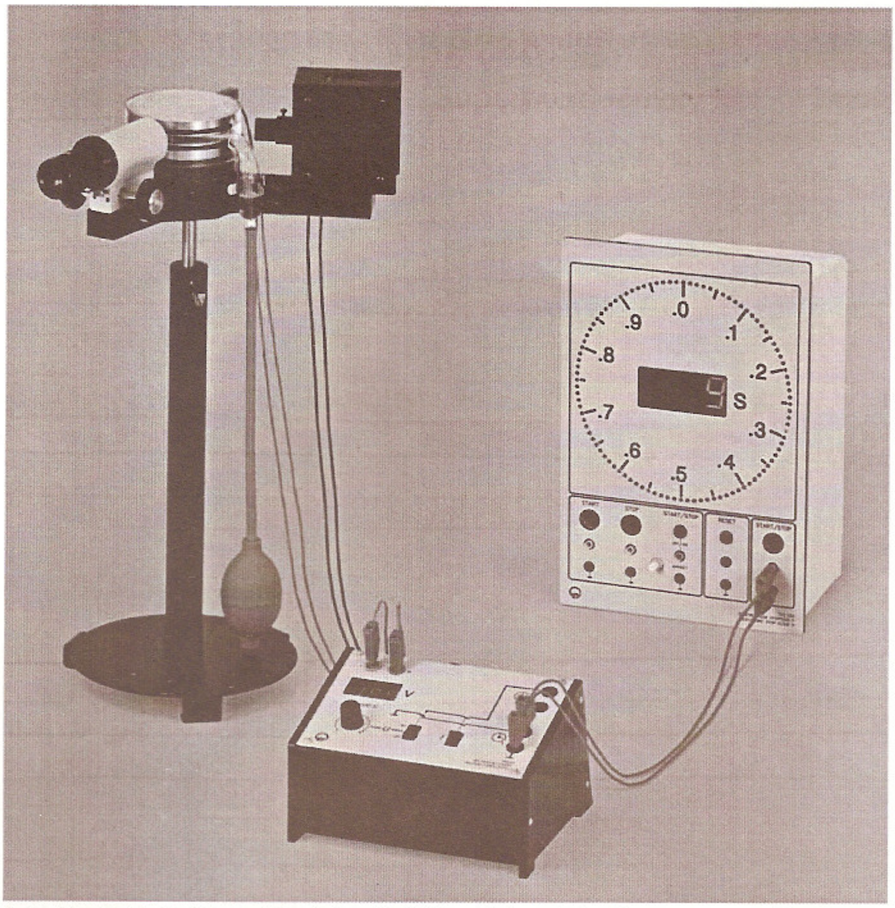
Millikan experiment

P 6.1.2.1 Determining the electrical charge of the electron after Millikan and demonstrating the quantum nature of the charge – measuring the suspension voltage and the falling speed

P 6.1.2.2 Determining the electrical charge of the electron after Millikan and demonstrating the quantum nature of the charge – measuring the rising speed and the falling speed

P 6.1.2.3 CASSY-S Determining the electrical charge of the electron after Millikan and demonstrating the quantum nature of the charge – measuring the suspension voltage and the falling speed with CASSY

P 6.1.2.4 CASSY-S Determining the electrical charge of the electron after Millikan and demonstrating the quantum nature of the charge – measuring the rising speed and the falling speed with CASSY



Determining the electrical charge of the electron after Millikan and demonstrating the quantum nature of the charge – measuring the suspension voltage and the falling speed (P 6.1.2.1)

With his famous oil-drop method, *R. A. Millikan* succeeded in demonstrating the quantum nature of minute amounts of electricity in 1910. He caused charged oil droplets to be suspended in the vertical electric field of a plate capacitor and, on the basis of the radius r and the electric field E, determined the charge q of a suspended droplet:

$$q = \frac{4\pi}{3} \cdot r^3 \cdot \frac{\rho \cdot g}{E}$$

ρ: density of oil
g: gravitational acceleration

He discovered that q only occurs as a whole multiple of an electron charge e.

His experiments are produced here in two variations. In the first variation, the electric field

$$E = \frac{U}{d}$$

d: plate spacing

is calculated from the voltage U at the plate capacitor at which the observed oil droplet just begins to hover. The constant falling velocity v_1 of the droplet when the electric field is switched off is subsequently measured to determine the radius. From the equilibrium between the force of gravity and Stokes friction, we derive the equation

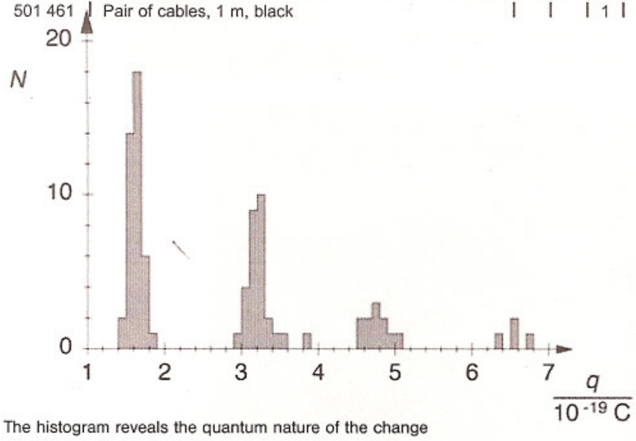
$$\frac{4\pi}{3} \cdot r^3 \cdot \rho \cdot g = 6\pi \cdot r \cdot \eta \cdot v_1$$

η: viscosity

In the second variant, the oil droplets are observed which are not precisely suspended, but which rise with a low velocity v_2. The following applies for these droplets:

$$q \cdot \frac{U}{d} = \frac{4\pi}{3} r^3 \cdot \rho \cdot g + 6\pi \cdot r \cdot \eta \cdot v_2$$

Cat. No.	Description	P 6.1.2.1	P 6.1.2.2	P 6.1.2.3	P 6.1.2.4
559 411	Millikan apparatus	1	1	1	1
559 421	Power supply for Millikan apparatus	1	1	1	1
313 033	Electronic stopclock P	1	2		
524 010	Sensor-CASSY			1	1
524 200	CASSY Lab			1	1
524 034	Timer box			1	1
501 46	Pair of cables, 1 m, red and blue	3	4	3	3
500 421	Connecting lead, 50 cm, red				1
	additionally required: PC with Windows 95/98/NT or higher			1	1
501 461	Pair of cables, 1 m, black			1	1



The histogram reveals the quantum nature of the change

Additionally, the falling speed v_1 is measured, as in the first variant. The measuring accuracy for the charge q can be increased by causing the oil droplet under study to rise and fall over a given distance several times in succession and measuring the total rise and fall times.